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Geology for Environmental Planning in Marion County, Indiana

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used about 82.8 mgd in 1972 from these three sources. These reservoirs also serve flood-control and recreational purposes.

MANAGEMENT

Surface water is managed through the use of reservoirs, levees, holding-infiltration ponds, ditching, stream maintenance, and erosion and quality (effluent-discharge) control. The major environmental considerations in surface-water management are: (1) water quality, (2) flow regulation, and (3) drainage.

WATER QUALITY

The maintenance of an acceptable level of water quality depends on control of contaminant discharge, maintenance of some minimum base-level flow, and control of erosion runoff. Contamination results from both point and area sources. Point sources include industrial and municipal wastes, and area sources may include sanitary landfills, septic-system fields, and agricultural fertilizers and pesticides. The base flow in a nonreservoir-fed stream is determined by the regional ground-water level, but that of the major streams in Marion County can be controlled by reservoir discharge. Natural surface-water quality is a reflection of ground-water quality plus dilution by surface runoff. Because surface water moves much more rapidly than ground water, it is much more variable in quality. Ground-water temperature varies within a small range, but surface-water temperature may range from freezing to more than 90° F. Water quality can best be controlled by maintaining a reasonably high flow rate to provide for dilution and self-purification and by minimizing the quantity of contaminants.

FLOW REGULATION

Flow regulation, or the maintenance of an adequate base-level flow and flood control, is a factor important to water supply, quality control, flood protection, and recreational usage. Flow is regulated by controlling discharge from reservoirs and by constructing levees that will increase carrying capacity. Flow is hindered by construction within the *flood plain* and by restrictive bridgeworks and culverts. For example, Pogues Run flows through a box culvert under the downtown business section of Indianapolis. The culvert will not carry peak flood flow, and the excess floodwater flows overland through the downtown area.

Another aspect of flow regulation is related to surface-construction projects. Parking lots, roadways, and buildings reduce infiltration and increase runoff. Agricultural ditching and tiling also increase surface flow. All the above factors, but not flood-control reservoirs, combine to increase maximum flood level and to reduce base flow level. Average annual streamflow for the larger perennial streams ranges from less than 1 cfs (cubic foot per second) to more than 25 cfs (fig. 7). Flood-plain information, including the expected magnitude of floods, has been studied by the U.S. Army Corps of Engineers and is available for the following streams: Pogues Run, Pleasant Run, and Bean Creek (Flood Plain Information, 1970b); Lick Creek and Little Buck Creek (Flood Plain Information, 1971a); Little Eagle Creek (Flood Plain Information, 1971b); and Crooked Creek and Williams Creek (Flood Plain Information, 1970a).

DRAINAGE

Poor drainage conditions may be either natural, as with upland tills, or construction related. Drainage of upland tills can be improved by tiling and ditching. Such drainage, however, could add to the flooding problem and should be planned cautiously. Construction-related drainage problems involve inadequate culverts and bridges as well as other obstructions constructed on the flood plain. Anything constructed on the flood plain that reduces its cross-sectional area will increase the flood level.

Ground-Water Resources

Ground water, water beneath the earth's surface and within the zone of saturation, along with previously discussed surface water, is one of the most abundant natural resources in Marion County. It is also a resource that is essential to continued development in the area. Ground water has decreased in relative importance to the city since the early 1900's and is now used only as a supplement or reserve. Industrial and domestic users, however, continue to rely heavily on ground water. With proper development and management, ground water can help meet the increasing water-supply demands of this growth-oriented community. There are limitations to water availability, however, that should be considered when planning for the future of the area. For a detailed review of ground-water resources in Marion County the reader is referred to Herring (1974, 1976), McGuinness (1943), and Meyer, Reussow, and Gillies (1975).

PRESENT USAGE

Ground-water usage in Marion County (1974) is estimated to be about 60 mgd (million gallons per day). This includes water pumped from thousands of domestic wells, hundreds of industrial wells, and dozens of municipal wells. Total ground water used is as follows: (1) industry, 29.0 mgd; (2) domestic, 9.0 mgd; (3) municipsl, 7.6 mgd; (4) commercial, 4.3 mgd; (5) institutional, 3.5 mgd; and (6) irrigation, 1.5 mgd. Industrial facilities, the largest users of ground water, are concentrated in the central part of the county and tap the most productive *aquifers* of the area. Domestic use of ground water is also quite high; about 100,000 people rely on private wells scattered throughout the county.

Water discharged from major sand and gravel operations and quarries in the White River valley and from other pits, building-construction sites, and sewer-construction projects scattered throughout the county are excluded from the water-usage figures. The exact amount of water being discharged by these dewatering operations is not known; during 1972, however, an estimated 23 mgd was being pumped into White River by major sand and gravel operations alone.

AVAILABILITY

The availability of ground water depends primarily on geologic and meteorologic conditions. Favorable conditions include: (1) a permeable surficial material that will permit ready infiltration of precipitation, (2) a thick coarse-grained or otherwise highly permeable geologic unit (aquifer) at some depth below the seasonal low water table, and (3) sufficient rainfall.

Ground water in Marion County is available from unconsolidated materials, primarily sand and gravel in the glacial drift, and from bedrock, mostly Silurian and Devonian limestone and dolomite. The most prolific source is the thick layer of sand and gravel of Pleistocene age in the glacial outwash in and adjacent to the White River flood plain.

Marion County has relatively large areas of flat-lying permeable alluvium, outwash, and kame materials that permit high infiltration rates. Along the major stream valleys the outwash extends to some depth beneath the surface to form an excellent aquifer. The Silurian-Devonian carbonate rocks lying at the bedrock surface and immediately beneath the outwash have undergone extensive solution-channel development and also constitute a good aquifer. Sand and gravel lenses within the till and the Silurian-Devonian carbonate rocks that lie beneath till (as opposed to outwash) are also aquifers but are not as prolific. Rainfall in the Marion County area exceeds *evapotranspiration*, thereby providing the excess water required to recharge the aquifer systems.

DEVELOPMENT POTENTIAL

The development potential or potential yield of an aquifer (fig. 8) depends on aquifer coefficients (*transmissivity*, *hydraulic conductivity*, and storage), aquifer thickness, areal extent, water levels (fig. 9), and recharge. On the basis of the above factors, the potential yield from ground-water sources in Marion County is an estimated 94 mgd (Meyer, Reussow, and Gillies, 1975). This yield can be achieved through location of wells and well fields in accordance with accepted hydrogeologic methods.

An aggressive program of artificial recharge and sound aquifer management could substantially increase the potential ground-water yield. An aggressive program includes the construction of holding ponds to permit the spreading of water over the land surface and for better infiltration and recharge, the possible use of injection wells so that surface

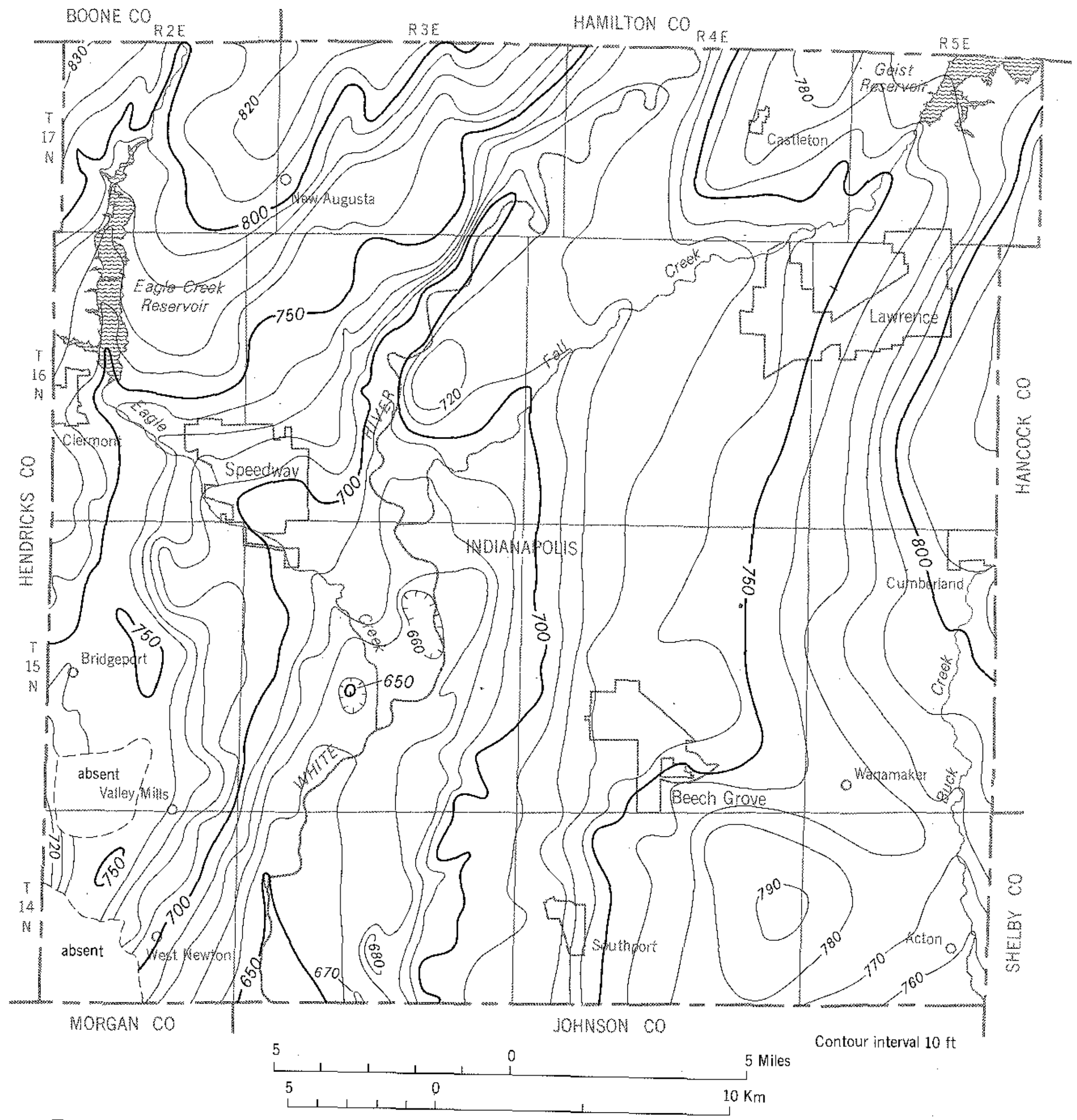

Figure 9. Map of Marion County showing the potentiometric surface of the principal Pleistocene aquifer.

water can be injected into the aquifer during periods of high streamflow, and the use of proper well spacing with controlled pumpage of production wells to avoid overdrafts and obtain the best possible yields.

PRINCIPAL PLEISTOCENE AQUIFER

The greatest development potential exists in the principal Pleistocene aquifer, an extensive system of sand and gravel deposits in the White River valley. This aquifer, which has all the requirements (continuity, thickness, recharge potential, and permeability) for prolific ground-water production, also extends to the east and west beneath the glacial-till cover (fig. 10). Recharge to the aquifer is very good because the soil cover is relatively permeable and allows a substantial amount of precipitation to percolate downward into the underlying aquifer. A perennial stream, White River, transects the area and is hydraulically connected to the aquifer, thereby providing substantial induced infiltration. The aquifer is near the surface, and the topography and present land use in much of the area are such that an extensive and effective artificial recharge system of canals, trenches, pits, or wells could be constructed. In places, particularly where it lies beneath a cover of till, the aquifer is divided into two units by a relatively thick and extensive till layer (fig. 10). In the White River valley and in the lower reaches of Eagle Creek and Fall Creek, the saturated sand and gravel deposits range from 30 to more than 80 feet in thickness and constitute the most productive area of the principal Pleistocene aquifer (fig. 10).

Much of the present ground-water withdrawal takes place in the northern section of the aquifer; little development has been directed toward the southern part.

BEDROCK AQUIFERS

The most productive bedrock-aquifer system in the county is composed of the limestone and dolomite formations of Silurian and Devonian age. These formations behave hydraulically as a single aquifer (fig. 10). The most productive zone is in the upper 100 feet in areas where it was once exposed at the bedrock surface. The greatest amount of solution development has occurred in this zone.

The Silurian-Devonian aquifer exhibits considerable variability in its ability to transmit water to wells. For example, in the western and southern parts of the county, where the aquifer is overlain by younger shales of Devonian and Mississippian age, the potential yield is much less than in the rest of the county, where it is overlain by glacial drift. The shales greatly retard the downward percolation of water and decrease the potential for solution-channel development and other processes that would permit rapid recharge of the aquifer.

On the other hand, the potential yield in the Silurian-Devonian aquifer in those areas where it is overlain by valley-train and outwash-plain deposits of sand and gravel is quite good. Not only has the bedrock been exposed to surficial weathering and more rapid solution-channel development, but it is also exposed to constant recharge from the overlying sand and gravel. Individual well yields of several hundred gallons per minute are common in these areas.

Where the Silurian-Devonian aquifer is overlain by glacial till, as in much of eastern Marion County, well yields are generally about one-half as great as where sand and gravel overlie the aquifer. One prominent exception is in the small well field of the town of Lawrence, where some wells are capable of producing 1,000 gpm. Apparently a relatively high degree of jointing and (or) solution-channel development has occurred there.

The potential yield of the New Albany Shale of Devonian-Mississippian age is very limited. Few wells are completed in this formation, which is as thick as 125 feet, because it has a relatively low yield and because more water can usually be found either above or below it. Where the New Albany Shale underlies the younger Borden siltstone and shale, it has a very low permeability and yields almost no water to wells. Where the New Albany lies immediately beneath the glacial drift, it is somewhat more highly jointed and weathered, and, consequently, the yields to wells tend to be higher. Nevertheless, many wells are dry and some